Artikel
Michael Stolz in conversation
with Chris Howe*

On the Borderline of Disciplines – Concepts of Reproduction and Copying in Molecular Biology and in the Humanities. A Conversation with Christopher Howe (Molecular Biology, Cambridge)

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Abstract: Der Beitrag gibt ein interdisziplinäres Gespräch zwischen dem Literaturwissenschaftler Michael Stolz (Universität Bern) und dem Molekularbiologen Christopher Howe (Universität Cambridge, UK) wieder. Eine wichtige Rolle spielt dabei die Frage nach dem Metapherngebrauch in der Beschreibungssprache molekularer Reproduktionsvorgänge: ‚Transkription' (Umschrift) der DNA in RNA, ‚Translation' (Übersetzung) der RNA in Proteine (Ribosome), ‚Replikation' (Rückbiegung) der DNA in neue Stränge. Diese Metaphorizität wird im Horizont geistes- und naturwissenschaftlicher Konzepte diskutiert, die bisher kaum in Zusammenhängen gesehen wurden, aber eine mitunter überraschende Nähe aufweisen: Zur Sprache kommen Hans Blumenbergs metapherngeschichtlicher Ansatz von der ‚Lesbarkeit der Welt', die in den Naturwissenschaften verbreitete Kautel „The price of metaphor is eternal vigilance" (Lewontin u.a.), Jean Claude Ameisens implikationsreiche These vom Zelltod als Gestaltungsprinzip des Lebens (‚La sculpture du vivant') und die Annahme einer zirkulären Kausalität in der jüngeren Krebstherapie (u.a. bei Michael Hendrickson in Auseinandersetzung mit Erwin Schrödinger). In diesem Kontext tendieren die Naturwissenschaften im Gegensatz zu den sprachskeptischen Geisteswissenschaften dazu, Begriffen wie ‚Transkription' und ‚Translation' ein wörtliches Substrat vor jeder metaphorischen Bedeutung zuzugestehen. Eine solche Wörtlichkeit aber würde in Zusammenführung natur- und geisteswissenschaftlicher Perspektiven zu dem folgenreichen Schluss führen, dass sich Kommunikation als ein Prinzip des Lebens erweist.

Keywords: Reproduktion, Metaphorizität, Transdisziplinarität, Geistes- und Naturwissenschaften

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Michael Stolz and Chris Howe had this conversation at Corpus Christi College Cambridge in June 2018. Both scholars work in different fields – Michael Stolz in medieval German studies, Chris Howe in biochemistry – but have collaborated at numerous opportunities and exchanged ideas at several interdisciplinary meetings over the last two decades. Chris Howe from the Department of Biochemistry at Cambridge University has become an esteemed partner for humanities scholars studying the transmission of manuscript texts and other cultural objects, as he is keen to share with them methods developed in molecular biology. The application of phylogenetic analysis, and especially the generation of computerised phylograms, is of great interest in so-called stemmatological studies, tracing the development of textual traditions in the manuscript age. Computer based phylograms can be used to generate an unrooted, network-like structure with a non-hierarchical shape that doesn't impose a necessary origin of descent, but emphasises group relationships instead.[1] This is similar to current stemmatological concepts developed by scholars who are sceptical to the idea that in a textual tradition indebted to oral performance there is one single textual ancestor or 'original'. Instead, they assume that in the premodern era before the printing age, texts developed as 'flexible' entities with a high amount of variation.[2] This process on the other hand can be compared to the phenomenon of mutation in microbiology.

1 Cf. Barbrook et al. 1989; Howe et al. 2001; Howe et al. 2004; Howe / Windram 2011.
2 Cf. Stolz 2015; Stolz 2017.

In this context, the conversation deals with phenomena of 'reproduction' and 'copying' common in the interlocutors' respective disciplines. The discussion concentrates on terms such as 'transcription', 'translation', 'replication', 'messengers', and 'emergence'. In this context, it turns to the question to what extent these terms are metaphorical, and to what extent metaphors are a helpful and even necessary vehicle of thinking in both relevant subjects. Furthermore, the discussion deals with linear and circular concepts describing the relationship existing between 'original' or 'exemplar' on the one hand and 'copy' on the other. The conversation then traces the material side of manuscript transmission, especially the one in parchment form, and deals with the fact that genealogies of this writing surface, produced from animal skin, can be analysed by molecular biological methods. The interlocutors finally reflect on the highly problematic potential involved in the usage of biological terms transferred to the subject matter of the humanities, when topics such as programmed cell death could be related to social or political concerns. The conversation also shows that an interdisciplinary dialogue is not always easy; at times the interlocutors even found themselves at cross-purposes. But even when touching the limits of interdisciplinary exchange, the discussion offers surprising new insights about the delineation between the sciences and the humanities. The conversation concludes with the idea that communication emerges as the most relevant principle in both fields, and that communication turns out to be a principle of life.

Michael Stolz: In this conversation we will discuss on an interdisciplinary level the idea of combining research approaches in microbiology as well as in the humanities, in philology and textual criticism. In the context of this volume, we are very much interested in the term of 'reproduction'. Might I ask you to explain in some sentences the meaning of this term in microbiology and in genetics?

Chris Howe: I suppose the simplest form of reproduction is what we would call asexual reproduction, when an organism makes an essentially identical copy of itself. That might be, for example, with bacteria that reproduce asexually, making more identical bacteria, sometimes also what one would define as clonal propagation – clone in that sense meaning identical copies. That is the simplest form of reproduction, where the progeny is by and large identical to the starting organism. Then there is a more complicated system which is sexual reproduction. Sexual reproduction is what you find in the groups of organisms that obviously include humans as well as biological kingdoms in general. In sexual reproduction, you have a blending of different versions of the gene from different individuals, and consequently that is a more complicated process: the progeny will have traits that they inherited from each parent but they will not be identical to each parent.

Michael Stolz: How common is this identical reproduction with reference to nonidentical reproduction? Could you compare in terms of numbers or percentage?

Chris Howe: In terms of numbers it's extremely common indeed, and indeed it happens as well in the cells in our body: All individual cells in our body, with a few exceptions, are derived by asexual reproduction from the fertilised egg cell. So, essentially all cells in the body are derived by asexual reproduction from the fertilised cell as with bacteria; as I say, they propagate by asexual reproduction. If you bear in mind that there are more bacterial cells in your gut than there are cells of you in the whole of your body, then that shows how very common on a numbers basis asexual reproduction is. But if you think of it in terms of the complexity of the species, then more complex species have sexual reproduction.

Michael Stolz: Could we say that asexual reproduction, including a high amount of identical reproduction, tends to be the norm, whereas sexual reproduction, introducing changes, would be the exception?

Chris Howe: I suppose you could say that, yes. And there are advantages in Darwinian terms to having sexual reproduction and population. Biologists have hypothesised over the years as to what the advantages are. It is clearly something that is advantageous, given the number of different groups of organisms that do it, but there is a cost for sexual reproduction as well.

Michael Stolz: We might be getting the impression that microbiologists are concentrating on the exceptional case of sexual reproduction, which is likely to be the more interesting kind of reproduction, as it produces changes.

Chris Howe: Well, you also have changes in the asexual reproduction. Bacteria for example that divide asexually are continually mutating. There is a process of changing by mutations arising in those organisms.

Michael Stolz: In cultural studies, we have a process, which could be considered similar to asexual reproduction: In the early modern printing age, compared to the preceding era of manuscript transmission, we encounter the phenomenon of mechanical reproduction, allowing for numerous identical copies coming out of the printing press. Could we consider this as being an equivalent to asexual reproduction?

Chris Howe: I suppose there the technical mechanism is equivalent to the one of enzymes that carry out the reproduction, as is the case for asexual reproduction.

Michael Stolz: There is even an important cultural theory, introduced by Walter Benjamin, saying that, if we are able to reproduce texts or works of art mechanically, they tend to lose their *aura* (*aura* implying a phenomenon of a distance, however close the text or work of art may be).[3] But we probably can't apply such a term, used in the humanities, in biological circumstances. Or would you think that there is an equivalent of *aura* in sexual reproduction?

Chris Howe: I think that is probably taking the analogy too far, as it would be difficult to see how one would apply that. But it is certainly the case that in some biological systems, having more and more copies of an individual cell generated by asexual reproduction, can change the behaviour of those cells. If you have for example bacteria that infect plants, and if you have just one or two of those bacteria in the vicinity of the plant, they will not infect it, but if you have a population of those bacteria, then that actually switches on enzymes in the bacteria that allow them to attack the plant. So, they will only attack the plant if there are enough of those bacteria around. If there's just one or two they do not. When the population is big enough that they can mount a serious attack on the plant then they go in and attack it. And that is a phenomenon that the biologists call *quorum sensing*: it is like a *quorum* for a committee, but the bacteria are able to sense, when there are enough of them around to yield a productive infection. So, it's interesting there that the consequences of the population size increasing actually allows the population to do things that individual cells do not do.

Michael Stolz: But that is a question of mere quantity, isn't it?

Chris Howe: Yes, that is true.

Michael Stolz: Let us turn to expressions like transcription, translation or replication in microbiological processes. In the context of microbiology, scholars of the humanities would consider them as highly metaphorical terms.[4] Could you explain them shortly from a biochemical perspective?

Chris Howe: In biological terms, the information in our cells is carried in the molecule DNA, deoxyribonucleic acid, but that is the information store, and the information is used by going through a kind of intermediate which is called RNA, often referred to as messenger RNA. Making the messenger RNA involves making a copy of the DNA. That messenger RNA is what is actually used to make the proteins. The proteins are the enzymes that cells are dependent on. It is that process of making a copy as RNA of the DNA that is transcription.
Further on, the 'decoding' (a term that biologists use), the 'decoding' of that information in the RNA to make proteins, is referred to as translation, because it is, as it were, a different language: Proteins are made of strings of amino acids, messenger RNA and DNA are made of strings of repeating units that are different from

3 Cf. Benjamin 2008 [1936]; English translation: Benjamin 2002 [1936].

4 We might think of Blumenberg 1998; English translation: Blumenberg 2010.

amino acids, they are called nucleotides. Therefore, the process of translation takes a molecule that is written in the nucleotide language and uses it to synthesise a molecule that is written in the amino acid language.
Finally, replication is the process of making an identical or nearly identical copy of a molecule: When cells divide they need to make a copy of the DNA so that each progeny cell has a copy of the DNA. And, although we think of DNA as being the most important molecule for replication, RNA will replicate as well. There are for example lots of viruses, such as the flu virus, that has RNA as its genetic material and can make an RNA copy of itself.

Michael Stolz: The entire vocabulary used in this context refers to communication. We speak of 'decoding', we have a 'messenger' transporting information, we have a 'transcription' (something is 'written' from one code into another), we have 'translations' (something is 'transferred' from one 'language' into another), we have 'replication' (something 'bends back'). – Are all these expressions merely metaphorical, or do they have a literal dimension? Do you actually have a kind of 'messenger' to transport something in this process, do you deal with a kind of writing here – or are these terms only used to help us to imagine what is going on in microbiological processes?

Chris Howe: That is an interesting question. I suppose it depends a bit on what you expect the characteristics of a messenger to be: one characteristic of a messenger is that it is taking information from one place to another, and it is certainly true that, not in bacterial cells but in other cells, the DNA, i.e. the store of information, is kept in a particular compartment in the cell, the nucleus, and the proteins are synthesised outside the nucleus, and the messenger RNA actually physically has to move from the nucleus, where it is made, to the compartment outside the nucleus, where it is utilised. So, there it is physically transferring information from one part of the cell to another.

Michael Stolz: But could we alternatively use other metaphors to describe the same process? So, for instance, could we speak of transport, could we speak of a vehicle, without referring to writing processes, without referring to communication?

Chris Howe: I think the words that are communication-based are more accurate, because they deal with the transfer of information. We use the term transport in biology, when, for example, a cell takes up a sugar from the environment. We say that the sugar is transported across the membrane. There is no information being transferred in that case, because there is a sugar outside the cell and the sugar is brought inside the cells. So, although the sugar is being relocated, there isn't really any information that's carried. Therefore, I think the words that imply an information process are the most helpful ones, and indeed the science of studying the genetic information in DNA is often referred to as bioinformatics, where it very much has that emphasis on information.

Michael Stolz: This is an interesting result. In microbiology and in the humanities alike, we deal with information: in literary studies, in art history or in similar disciplines, our basic topic is always information. If we analyse a novel, our central concern is the information contained in it, and how it is communicated; there are also questions of information processes, when a literary text is distributed in a society, or how a text can be performed, or how a text can be copied and rewritten, if we think of a manuscript culture. As microbiologists are also concerned with information, we could assume that there is a common epistemological base in both fields. However, natural scientists became very careful, when using metaphors: "The price of metaphor is eternal vigilance", as Richard Lewontin and others put it.[5] All the same, after what you have said, we might conclude that it isn't mere metaphor in the language we are using, but that there are real circumstances contained in these microbiological terms?

5 Lewontin 2000, pp. 4 and 131, quoting Arturo Rosenblueth and Norbert Wiener (not: Weiner, as Lewontin has it). – Lewontin gives Rosenblueth's and Wiener's article "Purposeful and non-purposeful behavior" as a source (Philosophy of Science, 17, 1950, pp. 318-326, not: Philosophy of Science, 18, 1951, as Lewontin has it); however, the quotation isn't contained in that article.

Chris Howe: I think there is definitely reality contained in them.

Michael Stolz: Might we pass over from reproduction to the topic of copying now? Perhaps, in scientific language there is a difference between reproduction and copying?

Chris Howe: I think, if by reproduction one means how one cell, or one organism can generate another cell or another organism, then that depends on a process of copying, whereby all the components in one cell can be duplicated to make two cells. So, copying of the molecules in the cell underlies the process of reproduction.

Michael Stolz: In copying, we encounter mutation, but we also encounter, what is called 'errors'. This implies that there is a kind of norm, which is correct, whereas there are also processes deviating from this norm. Is this the case in microbiology? Do you assume that there is a norm as well as a deviation, if something goes wrong?

Chris Howe: I think we would compare the products with the starting point, and so we would regard it as an error, or in biological terms a mutation, in the copying process, if the product is different in its sequence from the starting form. In DNA, we have, as I said, a string of units, called nucleotides of four different kinds: A (adenine), C (cytosine), G (guanine), and T (thymine) which refer to the components in them. The information in DNA really comes in the order in which those individual nucleotides come. The fact that ACG means something different from AGC, for example, is because the order of units is conveying information. I saw a very amusing cartoon at the time the human genome was being sequenced, in which one man in a white coat says to another: "It's wonderful, I've got the entire human genome sequence. The only problem is that the computer has put it in alphabetical order." And of course, that destroys all the information in it. So, it is the order, in which those units come, that has the information, and any change in that sequence then in biological terms we would regard as an error or a mutation.

Michael Stolz: But theoretically this mutation could also lead to a kind of improvement, isn't it? And then the term of 'error' wouldn't be adequate any more.

Chris Howe: Yes. If there were no errors in copying of DNA, then there would be no possibility of evolution. It is a very interesting balance that nature has to strike between having accurate replication (so that by and large all the information is kept – and that takes a certain amount of energy for the cell to keep the accuracy), and at the same time allowing a certain amount of 'error' so that there is variation on which natural selection can act to improve the species, or enable the species to adapt to their environment. So, you are absolutely right, a mutation, or an 'error' is not necessarily a bad thing, many mutations would be a bad thing, but under certain circumstances then an error may be beneficial. And what is beneficial in one environment may be detrimental in another.

Michael Stolz: You mentioned the nucleotides, abbreviated as A, C, G, T, which in pairs form the DNA's double helix structure, discovered by James Watson and Francis Crick in 1953.[6] At about the same time, another scientist, Erwin Chargaff, came very close to this structure in his research. In an article from 1970, Chargaff, who was also trained in literary studies, described how his ideas on the order of the DNA structure subsequently changed.[7] As he asserted, the DNA structure wouldn't correspond to a simple change of letters, as it occurs in the words *roma* and *rosa*. Rather, it would work like *roma* and *amor*, in which the whole sequence of characters is reordered inversely. Is it possible to describe nucleotides in these literal, but asemantic analogies of words?

Chris Howe: The mutations can be simple changes of one nucleotide for another, and they can be more significant changes affecting several nucleotides, which might involve flipping a piece around. In the cell, there is no bias, as it were, in the processes that give rise to mutation, as to whether the product is going to be functional. The mutation process is 'blind' in that sense. What natural selection does, is to pick out those mutants that actu-

6 Cf. Watson / Crick 1953.
7 Cf. Chargaff 1970, esp. p. 813.

ally have an improved or different function. Most mutations will probably destroy the function of the thing that is encoded, whereas a few mutations will improve its function.

Michael Stolz: In 1981, the German philosopher Hans Blumenberg published his *Legibility of the World*, dealing with the long-lasting human effort to 'read' the world like a book.[8] It is an old metaphor, already to be found in the Middle Ages, when theologians not only interpreted the Bible (the Book of Scriptures), but also the world (the Book of Nature) as a text written by the divine creator in order to be read. In his last chapter, Blumenberg refers to the 'genetic code', asking who might be the reader of this code – and again, we are confronted with a metaphoric context.

Chris Howe: I suppose at the cellular level the thing that reads the genetic code is a structure that we call the ribosome. And the ribosome is a complex piece of biochemical machinery that uses the information in the RNA to direct the synthesis of a particular protein. As I mentioned, proteins are made up of units called amino acids and just as is the order of nucleotides in DNA, i.e. the information in DNA, a function of a protein depends on the order in which particular amino acids come. In a sense, the ribosome is 'reading' the information in the messenger RNA, because it is 'translating' the order of nucleotides in the RNA into the order of amino acids in a protein.

Michael Stolz: But in that case we would assign the ability to read, normally accorded to human beings, to a natural entity. We would say the ribosome is capable of 'reading' something.

Chris Howe: It is 'reading', but in a very mechanical way, and it is 'translating' equally in a very mechanical way. So, I suppose an analogy might be, if I give you a piece of text in English and you translate it into German, then you are not simply turning one English word into one German word, but you are using your understanding of the English and your understanding of the German. Whereas, if I took the same piece of text and put it into Google Translate then that's a much more mechanical translation, and I suppose the ribosome is doing a Google Translate on the information in the RNA, rather than reading and translating in a way that requires thinking.

Michael Stolz: That means that we would have a kind of mechanical reading process in that case – something machines can do nowadays. That would be an interesting equivalent, probably.

Chris Howe: It is, I suppose, very similar to taking the changes in physical properties of a CD and converting that into sounds that you can listen to. That is essentially the process that is taking place. It is converting information in the physical structure of the CD into information in terms of sound.

Michael Stolz: And, actually, for these kind of technical devices we even use the word of 'reader'.

Chris Howe: Indeed, yes absolutely, and that's very much what the ribosome is doing when it's 'reading'.

Michael Stolz: 'Reading' in the humanities is always a reception process. We can 'read' a text as well as a work of art. Sometimes, when contemplating a text or an image, we suddenly discover something in its structure that we did not see before. It's a process similar to the one occurring, when we are looking at rebus or picture puzzles, and we suddenly recognise an old person instead of the young person we saw before, or we discover a crying face instead of the laughing one we initially saw. We also could think of a picture painted by an impressionist artist, in which, at a first glance, we would see only colour spots and then suddenly we would recognise a field of flowers or a river landscape coming up. Some humanities scholars call this phenomenon 'emergence'.[9] If you say the ribosome shows a mechanical reading process, would we find any comparable kind of 'emergence' there as well? Actually, the term of 'emergence' appears quite often in scientific articles, but it seems to be applied in a different way.

Chris Howe: The term is often used in biology to refer to emergent properties, i.e. describing how a

8 Blumenberg 1981.

9 Cf. Iser 2013.

series of small changes, in evolution for example, may result in a dramatic change in the organism. As a result of lots of small changes, there may be a kind of quantum leap that produces something very different, that biologists would often refer to as an emergent property. But that is a very specific usage. I suppose the equivalent to how the image emerges is probably how natural selection acts on the organism that has been produced as a result of the actions of the ribosome and everything else. So, the nearest equivalent is probably the interaction of the organism with its environment and other organisms – and that is really, what natural selection is.

Michael Stolz: Let us now turn to this point of natural environment. In studies tracing the line between the sciences and the humanities, environmental factors are stressed rather strongly, e.g. in a book dedicated to the impact of Erwin Schroedinger.[10] Considering environmental factors, we have the phenomenon of phenotype and of epigenetics, the study of changes in gene expression caused by mechanisms other than changes in the nucleotide sequence. In this context, the idea of network causality has become important, i.e. the idea that in reproduction or copying, there is not just a linear way from, let us say, the parents going to the children, but that we have to consider the whole environment instead. And perhaps in that circumstance, we even have to think about a circular causality, not leading from one point to another, but working in networks. How would you consider this idea of network for your area of study?

Chris Howe: I think there are lots of different levels at which one can think of those networks as existing. There is a lot of interest in biology at the moment in mapping the interactions of different proteins with each other. So, one protein in an organism will very often have some kind of physical contact with another protein and that contact will modify the properties of that protein, or the two together might then go and modify some other protein.[11] And just as we talk about the genome of an organism, meaning the sum of its genetic information, increasingly biologists talk about an interactome, i.e. the network interactions of different proteins with each other.[12] But then, one could take a look at the interaction of different organisms with others and at interactions of the organisms with the environment. I think the whole concept of epigenetics is a really interesting one, because that is where the environment can have an effect on the DNA, which can be stably transmitted without actually affecting the order of nucleotides in the DNA. It can affect the other chemical modifications that take place to the DNA molecules. Our DNA molecule, in spite of what I said before, is more than just a string of nucleotides. There are chemical modifications that can take place and those can be transmitted as the molecule is copied and those chemical modifications can be influenced by the environment. Therefore, the environment can bring about stably transmitted changes in the organisms, which almost is going back to the Lamarckian concept of the inheritance of acquired characteristics that we perhaps do not really consider as being a very good description of how evolution works, but actually I think people are starting to realise that it is a good description in some circumstances.

Michael Stolz: Perhaps, we might even adapt these models for the study of the transmission of medieval manuscripts. Quite obviously, certain changes in manuscripts are not just 'errors' made by a scribe nor simply voluntarily introduced changes, but they seem to be influenced by the scribe's environment. For instance, if a text was produced in the environment of a medieval court around 1200 and then rewritten in an urban context in the 14th or 15th century, when norms and manners had changed, that might influence the text itself. And I think this would also be comparable to what you have described now with environmental changes in cell biology.

Chris Howe: I've heard you talking about that, it's absolutely fascinating; I think it's a very interesting parallel to epigenetic changes in DNA.[13] But I suppose, another example of that kind

10 Cf. Gumbrecht et al. 2008, English translation: 2011, and there esp. Hendrickson, pp. 57-112 / pp. 45-103; see also Noble 2006.

11 Cf. for example de Vries / Howe 2007.

12 Cf. for example Vidal / Cusick / Barabasi 2011.

13 Cf. Stolz 2017.

might be the annotations of a text. So, if someone who has a particular text makes some annotations and then those annotations get copied within the text itself, then the scribes are not altering the text itself, but they are annotating it and that annotation is transmitted and those annotations would be just like the chemical modifications of the DNA in the epigenetic. So, I think it would be very interesting to try to understand more about those kinds of epigenetic changes.

Michael Stolz: However, in manuscript studies we rarely have the exemplar and the copy preserved. This is only the case in some exceptional circumstances, e.g. with two manuscripts of Wolfram von Eschenbach's *Parzival* (composed shortly after 1200), which were written in the 14th century: Karlsruhe, Badische Landesbibliothek, Donaueschingen 97, and Rome, Biblioteca Casanatense, Ms. 1409.[14] As recent research has brought to light, the copy preserved in Rome today belongs to a Franconian scriptorium, in which other related texts composed by Wolfram von Eschenbach and his successors were written.[15] And I think we could judge the Roman copy not just with respect to its exemplar from Karlsruhe, but also in the context of the other manuscripts produced in that scriptorium, which, with their special textual shape, are likely to have influenced the text of the Roman manuscript. The idea would be to look at the habits of copying in the relevant scriptorium for studying the special character of the Roman copy whose text differs considerably from the Karlsruhe exemplar. And I think one could approach this kind of research with an epigenetic point of view. – In microbiology, however, you normally would have available an 'exemplar' and a 'copy' of a gene sequence, is that right?

Chris Howe: We would typically, if we are comparing the DNA sequences of a group of organisms. If we wanted to work out what was present in the ancestor of that group, we would typically look at a related group, we call that the outgroup, and use that to infer something about the ancestor of the particular group. That is because on an evolutionary scale, it is much more difficult to know what the ancestor looks like. But if we are dealing much more with extant organisms, then we might know the DNA sequence of a particular bacterium and then have access to the DNA sequence of a bacterium derived from it. And we would know what the original one was.

Michael Stolz: In microbiology, you also have the phenomenon of lateral gene transfer, corresponding to what we would call contamination in manuscript studies (the fact that a scribe copied subsequently or even simultaneously from two or more exemplars). There is a famous quotation in textual criticism that in stemmatological studies, reconstructing the pedigree of a textual transmission, we are unable to cope with contamination, as there is no remedy against it.[16] Do you have remedies against lateral gene transfer in biogenetics?

Chris Howe: You are right, there is a very clear similarity with the process of lateral gene transfer, where DNA from an unrelated organism is acquired by a particular organism. A very good example of that would be the acquisition of DNA encoding antibiotic resistance in bacteria, the fact that bacteria can transfer DNA laterally is the reason why antibiotic resistance spreads so rapidly in bacteria. That would be a very clear parallel to contamination. There are some methods in biology that we can use to identify that this has happened. The composition of the DNA may be slightly different in terms of the numbers of A, C, G, T depending on where it came from. Therefore, a piece of DNA that came in by lateral transfer might have a slightly different composition from the surrounding DNA. Alternatively, one may be able to use computer programs that detect changes arising from a process that we call recombination, whereby you make a hybrid between two molecules. Recombination isn't really exactly the same as lateral gene transfer, because it is using two closely related individuals and making a hybrid between them and that is part of sexual reproduction. But we have computer programs that allow us to identify the points at which recombination took place. And in some instances of manuscript contamina-

14 Cf. the digital edition of the two manuscripts of the so-called *Rappoltsteiner Parzifal*: http://www.parzival.unibe.ch/rapp/index.html#/ (last accessed July 15th 2019).
15 Cf. Fasching 2018.
16 Cf. Maas 1957, p. 31: "Gegen die Kontamination kein Kraut gewachsen."

tion then one can use those programs to identify where, for example, a scribe has changed from one exemplar to another.[17] I think what is much more difficult, is where you have biological processes giving rise to a patchwork of material and the analogy to that might be a scribe who is constantly referring to a number of different witnesses and exemplars and making their preferred copy (i.e. the phenomenon of simultaneous contamination, mentioned above). I think that is as difficult for biologists to map as it is for textual critics. That is certainly the kind of contamination that would pose the biggest problems.

Michael Stolz: As I understand, besides these questions of textual evolution, you are also familiar with DNA-analysis on parchment.

Chris Howe: We have done a little work in actually characterising at the genetic level of the vellum of a manuscript. One could use, in principle, genetic fingerprinting technologies to try to identify kind of hallmarks of the vellum that were used in particular scriptoria, so that, if you had a witness with uncertain origin, you might be able, by characterisation of the DNA in the parchment itself, to work out where it came from.

Michael Stolz: But for this kind of research you have to take a part of the vellum?

Chris Howe: Yes, but you may not need very much. And there are people in York doing interesting work, as they basically just use a little eraser to rub off a small amount of DNA material from the surface that can give enough material to get genetic information out of it. Certainly, a really hard-line conservator would refuse that, arguing that even by taking DNA out of it, one is changing the properties of the manuscript. I think one needs to assess the value of the information that one could get by making a small change to it that would be really undetectable. We wondered about techniques, whereby one might be able to use electric fields to almost literally pull DNA out of the parchment (electrophoresis), and that wouldn't be invasive to the parchment itself, but would kind of suck some of the DNA out. Again, the hard-line conservators say by taking out DNA one changes the manuscript, but others say no, the information one can get would far outweigh the changes that are made to the item.

Michael Stolz: And what would be the aim of that kind of research? We could say that it is taken from a certain flock or from a certain area?

Chris Howe: Yes, in principle. I think the DNA in a piece of parchment is determined by three things. One is the genetics of the animal that gave rise to the parchment. Second is how the parchment was prepared, because very often a lot of skins would be put together in the same tank as part of the process for the removal of hair and so on, and actually DNA might diffuse from one into another. So, you might get some mixing of the DNA between parchments, between skins. And the third thing is again contamination, but in another sense: between people who have touched the parchment transferring their own DNA onto the parchment. So, there might be those resources.

Michael Stolz: And DNA-analyses would actually be able to detect this?

Chris Howe: If someone has, for example, licked their fingers and turned the pages, then there might be DNA transferred. I think certainly the DNA that comes from the actual skin itself could provide you with information on the flocks that were used to make the parchment, because one would expect genetically very closely related skins, or closely related animals to give skins that have very closely related DNA sequences. Maybe the extent of transfer of DNA of different species into, for example, a piece of cow vellum might actually be a signature of the processing techniques in the parchment manufactory. So, the first set of information could be very valuable, the second might give you a kind of refinement on it. I think, so far, we just do not have enough information to know, but it is a really interesting possibility.

Michael Stolz: Let us now come to a final point: The French physician and scholar Jean Claude Ameisen describes cell death arguing that in the body cells have continuously to die to maintain life.[18] He relates these processes also to myth,

17 Cf. Howe et al. 2001.

18 Cf. Ameisen 1999 and 2007.

to literary writing, and art, where we encounter similar descriptions of people interacting or of people dying, enabling a society to live on. A first question in this context would be: How relevant is this phenomenon of programmed cell death for microbiology and how right is Ameisen claiming that this continuous process is basic for the maintenance of the organism?

Chris Howe: Cell death is a very important and actually complicated process. Biologists now recognise a number of different kinds of cell death, each triggered by different signals and brought about by different mechanisms. Those kinds of cell death can be very important over the development of the organism. If, for example, a piece of tissue needs during development to separate into two connected, but recognisably different bits of tissue, then cell death may be needed to separate the one bit of tissue into two separate bits of tissue. Therefore, it could be an important development process. Cell death surprisingly is actually also important even in bacteria. One would think that any kind of programmed cell death in bacteria would be pointless, because the bacterium would then just die. But it turns out that in the case of, for example, infection of bacteria by viruses, there is a strong selective advantage for the population as a whole for a bacterium responding to a viral infection by dying, before the viral infection has gone to completion. The consequence of that is that no more viruses are produced and although the one bacterium that was infected dies, the rest of the population remains unscathed. If that did not happen, then the bacteria would have been killed by the virus anyway, but more viral progeny would have been liberated and they would have infected the other bacteria. We realise now in microbiology, that this process of abortive infection, as it is called, can be very valuable for protecting populations of bacteria against the effects of viruses. It is counterintuitive, but quite remarkable that even in single celled organisms programmed cell death can be very important for the species as a whole.

Michael Stolz: If we return to the phenomenon of metaphors in that case, we might say that a population might be protected or even preserved, if a part of the population dies. Transferring this idea into societal circumstances, would have terrible consequences. It immediately reminds us of cases of ideological genocide in the past and in the present. Ameisen addresses exactly this problem, stating that applying the Darwinian idea of natural selection to social and political life would entail the traps and dangers of socio-biology.[19] – How dangerous would this transfer of biological ideas into the socio-political sphere be? Would you see any relevance of this kind? One could stay purely in the sciences and just describe the phenomenon, but how is it relevant, if we consider it on the level of social impact?

Chris Howe: I think that is going outside my expertise as a biologist. But you are right, at the level of the bacterial population or the individual developing human it seems perfectly reasonable that a few cells might die for the organism as a whole, or the species as a whole, to be protected or to develop normally. But to try to apply that in society would be a very different and problematic thing of course.

Michael Stolz: Perhaps, here we also see the limits of the use of metaphors. Concerning programmed cell death, there is a developed scientific terminology which, when it is transferred to other areas, becomes precarious, however stimulating Ameisen's references to myth and art might be.

Chris Howe: I suppose one of the big differences is that in society each individual has their own value, whereas natural selection doesn't place any particular value on any one individual. But you are right, there is clearly a limit how one can reasonably apply ideas in one setting to another.

19 Cf. Ameisen 2007, pp. 1282-1283: "C'est dans la tentation de prendre exemple, dans la recherche fascinée d'une forme de 'loi naturelle' propre à fonder ou à justifier le fonctionnement de nos sociétés que sont nées, et naissent encore, les pièges et les dangers de la sociobiologie[]. La fin du XIXe siècle et la première moitié du XXe siècle ont révélé les dérives du 'darwinisme social' – les tentatives d'applications sociales et politiques, à la fois scientifiquement aberrantes et moralement indignes, des 'lois naturelles' que révélaient la théorie darwinienne de l'évolution du vivant et de la sélection naturelle."

Michael Stolz: We are touching ethical questions at this point. Is there an ethics in biological processes?

Chris Howe: I do not think natural selection knows any ethics. I think the only ethic is survival in natural selection.

Michael Stolz: This might sound like a rather disenchanting conclusion for an interdisciplinary conversation situated on the borderlines of the sciences and the humanities. However, in our discussion we touched numerous points of overlap in both fields. This seems to me especially relevant in the context of our exchange on copying processes with respect to phylogenetics and manuscript transmission. Listening to the reflective remarks you made above, we might conclude that communication, with all its implied processes of reproduction and copying, plays such a fundamental role in both the sciences and the humanities, that it might count as a principle of life.

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